

# QUANTIFYING THE BENEFITS OF NEW PRODUCTS: THE CASE OF THE MINIVAN\*

AMIL PETRIN

*University of Chicago*

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**Correspondence to:** Amil Petrin, Graduate School of Business, University of Chicago, 1101 E. 58th St., Chicago, IL 60637. phone: (773) 834-2861. Internet: [amil.petrin@gsb.uchicago.edu](mailto:amil.petrin@gsb.uchicago.edu), WWW:<http://gsb.uchicago.edu/fac/amil.petrin>

## **Abstract**

I develop a technique useful for obtaining more precise estimates of demand and supply curves when constrained to market-level data. It augments the estimation routine with information that relates the average demographics of consumers to the characteristics of the products they purchase. This extra information plays the same role as consumer-level data, allowing estimated substitution patterns and (thus) welfare to directly reflect demographic-driven differences in tastes for observed characteristics. I apply the technique to the automobile market, estimating the economic effects of the minivan introduction. I show that models estimated without micro data yield much larger welfare numbers than the model using them, primarily because the micro data appears to free the model from a heavy dependence on the idiosyncratic logit “taste” error. I complete the welfare picture by measuring the extent of first-mover advantage and of profit cannibalization both initially by the innovator and later by the imitators. My results support a story where large improvements in consumers’ standard of living arise from competition as firms cannibalize each other’s profits by seeking new goods that give them some temporary market power.

# 1 Introduction

Consumers benefit from a greater breadth of choice in both the kind and quality of products over time. Firms are the driving force behind these improvements, usually seeking the transitory market power associated with being the first-mover. This source of economic growth can be seen in products ranging from automobiles and consumer electronics to health care.<sup>1</sup>

In this paper I estimate the change in consumer welfare from the minivan introduction. I also infer the changes in producer surplus, measuring the extent of first-mover advantage and the profit cannibalization that took place both initially by the innovator and later by the imitators. My results suggest the introduction generated large welfare gains for consumers and surplus for the innovator at the expense of the other producers.

I follow the random coefficients discrete choice approach taken in Berry, Levinsohn, and Pakes (1995) (hereafter BLP), which allows substitution patterns to reflect consumer-level

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<sup>1</sup>Welfare consequences of new product introductions have recently received increased attention from economists (in particular, see Bresnahan and Gordon (1997).) Papers focusing on buyer benefits from new products cover a range of goods, including automobiles (Feenstra (1988), Berry, Levinsohn, and Pakes (1993), Fershtman and Gandal (1998)), computers (Bresnahan (1986), Greenstein (1994)), health care technology (Trajtenberg (1989)), breakfast cereals (Hausman (1997a)), telecommunications services (Hausman (1997b)), and cellular phones (Hausman (1999)). New products have also been the focus of economists' attempts at revising the Consumer Price Index, in part because of findings by Armknecht (1984) that changes in the index are mostly due to price inflation that accounts for new products and quality changes in existing products.

heterogeneity in tastes for observed product characteristics.<sup>2</sup> Modeling this heterogeneity is important when estimating demand elasticities, although the estimates tend to be imprecise when constrained to market-level data. Goldberg (1995) and Berry, Levinsohn, and Pakes (1998) utilize consumer-level data to improve these estimates.

I offer an alternative approach when consumer-level data are not available: augment the market-level data on sales and characteristics with information that relates the *average* demographics of consumers to the characteristics of the products they purchase. The extra information plays the same role as consumer-level data, allowing estimated substitution patterns and (thus) welfare to directly reflect demographic-driven differences in tastes for observed characteristics. For example, observing average family size conditional on minivan purchase and asking the model to reproduce this same average helps to more precisely identify the taste term relating families and minivans. Similarly, matching probabilities of purchase conditioned on different income levels helps to identify income effects. Since this approach requires only a modification of the BLP objective function, it adds no real computational burden to their method.

This approach can be useful for any market where information on purchaser aggregates is available. In the minivan case, I add information on new vehicle purchasers from the Consumer Expenditure Survey. I estimate four different demand-side specifications and find the models without the micro data yield welfare estimates that are much larger than the model with them. I also find that *only* the welfare estimates implied by the micro

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<sup>2</sup>Characteristics-based models were introduced by Gorman-Lancaster and developed econometrically in McFadden (1981).

data are free from a heavy dependence on the idiosyncratic logit “taste” error.

The paper is organized as follows. Section 2 provides a brief history of the minivan introduction. Section 3 reviews recent advances in discrete choice estimation. Section 4 outlines the utility specification and Section 5 discusses the supply side. The different sources of data are covered in Section 6 and the estimation procedure is outlined in Section 7. Sections 8 and 9 report results and conclusions.

## 2 The Minivan Innovation

In the early 1970s Ford proposed the “Mini/Max”, an alternative to the family station wagons and full-size vans of the day. This functional box-like vehicle provided much of its interior space through its height instead of its length or width, and it came equipped with front wheel drive, which permitted the floor of the passenger compartment to be lowered, adding more interior space, making entry easier, and allowing passengers more movement inside the vehicle. The “Mini/Max” idea received little support from Ford management who raised concerns about cannibalizing their strong station wagon sales.<sup>3</sup>

Introduced in 1984 by the financially troubled Chrysler Corporation, the Dodge Caravan (their minivan) was an immediate success, with sales of 170,000 in its debut year. General Motors (GM) and Ford quickly responded, introducing their own versions of minivans in 1985 (GM Astro/Safari) and 1986 (Ford Aerostar.) However, they were unprepared for the Caravan’s success and were forced to build their minivans on truck

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<sup>3</sup>Much of the discussion in this section comes from Yates (1996) and from industry publications.

platforms with rear-wheel-drive, resulting in minivans that handled more like down-sized full-size vans than passenger cars.

Chrysler continued to dominate this market niche over time, in part by adding popular features like a larger engine and a second sliding door. Fourteen years after the introduction, with six firms marketing a total of thirteen different minivans, Chrysler obtained 44% of the total 1.16 million units sold that year. Over the same time period Ford and GM watched as both their own and Chrysler's minivans cannibalized station wagon sales; after peaking in 1984 at 950,000, wagon sales fell to 300,000 over the next seven years.

### 3 Estimating Discrete Choice Demands

#### 3.1 Overview

Discrete choice models start with conditional indirect utility,  $u_{ij}(\theta)$ , given as a function of observed and unobserved product  $j$  and consumer  $i$  characteristics and model parameters  $\theta$ , and often written as

$$u_{ij}(\theta) = \delta_j(\theta) + \mu_{ij}(\theta) + \epsilon_{ij}.$$

The first component,  $\delta_j(\theta)$ , is a product-specific term common to all consumers. The  $\mu_{ij}(\theta)$  term captures heterogeneity in consumer tastes for observed product characteristics.  $\epsilon_{ij}$  is a “love of variety” taste term that is assumed to be independent and identically distributed (i.i.d. ) across both products and consumers. Consumer  $i$  is assumed to choose the product  $j$  that yields maximal utility, and market shares obtain from aggregating over consumers.

The utility component common to all consumers,  $\delta_j$ , is usually given as

$$\delta_j = -\alpha p_j + X_j \beta + \xi_j$$

where  $\alpha$  is the marginal utility of income,  $X_j$  and  $\beta$  are, respectively, a vector of observed product characteristics and the taste parameters associated with those characteristics.  $\xi_j$  represents utility derived from characteristics observed by consumers and producers but not observed to the econometrician. If these omitted characteristics are positively correlated with price, estimates of the price sensitivity term  $\alpha$  will be biased toward zero (see, e.g. Trajtenberg (1989).) Instrumental variable (IV) methods are the usual solution, although their application is frustrated by the fact that both the  $p_j$  and  $\xi_j$  enter the market share equation in a non-linear way. Berry (1994) provides an important advance, developing a method that makes IV applicable to a large class of these models.

BLP show that allowing substitution patterns to reflect heterogeneity in consumer tastes for observed product characteristics (i.e.  $\mu_{ij}(\theta) \neq 0$ ) is important when estimating demand elasticities.<sup>4</sup> The usual approach is to assume these tastes come from some distribution (e.g. multivariate normal.) Precise estimates of this distribution's parameters obtain when good information on how consumers substitute is observed. Market-level

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<sup>4</sup>When taste heterogeneity for observed product characteristics is ruled out, the only consumer heterogeneity arises from the i.i.d.  $\epsilon_{ij}$ 's. In terms of substitution patterns, the implication is that all consumers share the same expected ranking over the products (that given by the  $\delta_j$ 's.) Thus, any consumer facing a price increase in her first choice that induces substitution is always most likely to substitute to vehicles that are on average most popular, regardless of the characteristics of her first choice.

data may not provide much variation along these dimensions.<sup>5</sup> Goldberg (1995) and Berry, Levinsohn, and Pakes (1998) use consumer-level data to overcome this problem.

### 3.2 Identifying Taste Heterogeneity Using Aggregate Data

When consumer-level data are not available, an alternative is to add to the market-level data information that relates the *average* demographics of consumers to the characteristics of the products that they purchase. The extra information plays the same role as consumer-level data, allowing estimated substitution patterns to reflect demographic-driven differences in tastes for product characteristics.

The approach adds the relevant omitted demographics and their associated parameters to the model. For a given set of parameter values and household demographics the model yields predictions of individual household behavior. The implied market-level averages obtain using the model and the distribution of household-level demographics in the market

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<sup>5</sup>The identification obtains in part from observing variation in choice sets. Consider a market with three cars that differ only in the amount of their interior space with two cars having lots relative to the third and each car obtaining a market share of one-third. Suppose in a second market (in the following year or in a different geographic region) one of the vehicles with lots of interior space is no longer available. If the remaining vehicle with lots of interior space obtains two-thirds of the market, then its consumers appear to substitute based on interior space, suggesting they have strong taste for this characteristic. Furthermore, they disagree with the consumers purchasing the car with limited interior space, suggesting heterogeneity in tastes for interior space exists. However, if the two remaining vehicles split the market share, there is no evidence of heterogeneity in taste (consumers appear to randomly sort between the two available alternatives).

(by averaging over households). I include the difference between the observed market-level averages and the model predictions for them as new moments in the objective function. These moments improve precision by providing a penalty for parameter values with model predictions that are different from the data.

In this paper I match the model predictions to some averages describing new vehicle purchasers obtained from the Consumer Expenditure Survey (CEX). In particular, I match the model's probability of new vehicle purchase for different income groups to the observed conditional purchase probabilities from the CEX. I also match model predictions for average household characteristics (like family size) for purchasers of different vehicles to those in the CEX data. Substitution patterns and (thus) welfare numbers may then better reflect income effects or differences in tastes for minivans and station wagons that derive from differences in family size.

## 4 The Utility Specification

I tailor the utility specification to approximate substitution patterns among family vehicles. The utility function has consumer  $i$  choosing the good  $j$  that maximizes

$$u_{ij} = \alpha_i \ln(y_i - p_j) + X_j \beta + \sum_k \gamma_k \nu_{ik} x_{jk} + \xi_j + \epsilon_{ij},$$

where  $X_j, \beta, \xi_j$ , and  $\epsilon_{ij}$  are as described in Section 3 and  $x_{jk} \in X_j$ . Utility from the composite commodity good is given by  $\alpha_i \ln(y_i - p_j)$ . I allow the marginal utility of

income to vary according to income groups:

$$\alpha_i = \begin{cases} \alpha_0 & \text{if } (y_i \leq \bar{y}_1) \\ \alpha_1 & \text{if } (\bar{y}_1 \leq y_i < \bar{y}_2) \\ \alpha_2 & \text{if } (y_i \geq \bar{y}_2) \end{cases}$$

where  $\bar{y}_1$  and  $\bar{y}_2$  divide the U.S. population into three equally sized groups ordered by income. The  $k$ th characteristic of vehicle  $j$  is given by  $x_{jk}$ , for  $k = 1, \dots, K$ . Each consumer  $i$  has  $K$  idiosyncratic tastes for the  $K$  observed characteristics,  $\nu_i = (\nu_{i1}, \dots, \nu_{iK})$ . The consumer specific  $\nu_{ik}$  are interacted with  $\gamma_k$ , a parameter measuring the heterogeneity in tastes for the observed characteristics in the population. This yields  $\gamma_{ik}$ , consumer  $i$ 's personal taste for characteristic  $k$ ,

$$\gamma_{ik} = \gamma_k \nu_{ik}.$$

I allow the  $\gamma_{ik}$ 's associated with minivans, station wagons, full-size passenger vans, and sport-utility vehicles to depend on demographics. Specifically, if  $f s_i$  is the family size of household  $i$ , and, for example,  $mi$  and  $sw$  subscripts denote minivan and station wagon, consumer  $i$ 's tastes are

$$\gamma_{i,mi} = \gamma_{mi} \ln(f s_i) \nu_{i,fv}$$

$$\gamma_{i,sw} = \gamma_{sw} \ln(f s_i) \nu_{i,fv},$$

where  $\nu_{i,fv}$  is a common idiosyncratic taste  $i$  has for family vehicles (independent of demographics) and  $(\ln(f s_i) \nu_{i,fv})$  is the full demographic-dependent taste term. The parameter  $\gamma_{mi}$  ( $\gamma_{sw}$ ) is a taste-shifter that allows families of different sizes to value minivans (station wagons) differently. With this parameterization, the covariance between taste for

minivans and taste for station wagons is increasing in  $\gamma_{mi}$  and  $\gamma_{sw}$ . Thus, patterns of substitution between family vehicles can emerge for 2 reasons: larger families prefer these vehicles, and/or the vehicles share other similar observed characteristics.

After integrating over  $\epsilon_{ij}$ , which is assumed to have a type 1 extreme value distribution, the probability household  $i$  purchases good  $j$  is given by:

$$Pr(j|X, i) = \frac{e^{\alpha_i \ln(y_i - p_j) + X_j \beta + \sum_k \gamma_k \nu_{ik} x_{jk} + \xi_j}}{\sum_l e^{\alpha_i \ln(y_i - p_l) + X_l \beta + \sum_k \gamma_k \nu_{ik} x_{lk} + \xi_l}}$$

Aggregate demands  $s_j$  obtain from integration over  $i$ , which indexes demographics and the vector of unobserved tastes. For demographics I use the empirical distribution function from the CEX to approximate the demographics of U.S. households. I use  $K$  independent  $\chi^2(3)$  distributions truncated at 95% to approximate the distribution of unobserved consumer tastes for two reasons: these distributions are bounded above and below, and they imply that taste heterogeneity in the population is skewed in the direction of positive taste.

## 5 The Supply Side

I use the supply side approach from BLP to approximate competition in the new vehicle market. There are  $F$  multiproduct firms competing in a Bertrand-Nash fashion; given their products and the prices and attributes of competing products, firms choose prices to maximize profits. Each firm  $f$  produces some subset  $J_f$  of the  $J$  total products. Firms have a marginal cost function that is log-linear in a vector of  $k'$  cost characteristics.

Similar to the demand side, the cost characteristics are separated into an observed and an unobserved component. The vector  $W_j$  represents the observed component, and  $\omega_j$  the unobserved component. Given these assumptions, the (log) marginal cost function can be written

$$\ln(mc_j) = W_j\tau + \omega_j, \quad (5.1)$$

where  $\tau$  is the vector of cost parameters, and an estimate of  $mc_j$  obtains from the demand side model and the equilibrium notion in a manner I now describe.

Each firm has a profit function

$$\Pi_f = M \sum_{j \in J_f} (p_j - mc_j) s_j(p, X; \theta),$$

where  $M$  is the number of households in the U.S.,  $s_j(\cdot)$  is good  $j$ 's predicted market share, and  $q_j(p, X; \theta) = M s_j(p, X; \theta)$ .<sup>6</sup> The  $J$  first order conditions for static price competition are given by

$$s_j(p, X; \theta) + \sum_{r \in J_f} (p_r - mc_r) \frac{\partial s_r(p, X; \theta)}{\partial p_j} = 0, \quad (5.2)$$

for  $j = 1, \dots, J$ . This system of equations can be inverted to solve for the marginal costs that enter (5.1), or

$$mc = p - \Delta(p, X; \theta)^{-1} s(p, X; \theta), \quad (5.3)$$

where  $\Delta(p, X; \theta)$  is the appropriately defined matrix of own- and cross-price share derivatives that has as elements  $\frac{\partial s_r(p, X; \theta)}{\partial p_j}$ , and  $mc$ ,  $p$ , and  $s(p, X; \theta)$  are respectively the vectors

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<sup>6</sup>This profit function ignores the 25% tariff levied against Japanese minivans during the 1980s. While it is possible to incorporate this tariff into the model, I do not add this complication because Japanese minivans make up a very small part of total minivan sales.

of marginal costs, prices, and market shares.

I also use (5.2) to solve for new equilibrium price vectors under different counterfactuals. A new equilibrium price vector  $p_{cf}$  that obtains under a counterfactual choice set (e.g. one without minivans) solves (5.2) for the choice set. The new price vector  $p_{cf}$  is used to compute the change in variable profits under the counterfactual for each firm  $f$ , or  $\Pi_f(p_{cf}, mc; \theta) - \Pi_f(p_0, mc; \theta)$ , where  $p_0$  is the initial set of prices.  $\sum_f (\Pi_f(p_{cf}, mc; \theta) - \Pi_f(p_0, mc; \theta))$  then gives the total change in producer profits.

## 6 Data

I use two data sets. One contains market-level information on new vehicles and the second contains information on new vehicle purchasers.

The new vehicle data set includes all 2407 nameplates marketed in the U.S. from the years 1981 to 1993 with sales over 1000 vehicles. It is a combination of information from *Automotive News Market Data Book* and *Wards Automotive Yearbook*, with most information on passenger cars coming from the former, while the latter provided information on station wagons, minivans, sport-utility vehicles, and full-size passenger vans.<sup>7</sup> Vehicle characteristics include a measure of acceleration (horsepower/curb weight), vehicle dimensions, drive type, fuel efficiency, and a measure of luxury (air-conditioning standard.)

Quantity sold and list price are linked to the characteristics of the base model to produce

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<sup>7</sup>My thanks to BLP for providing me with the data on passenger cars and to Rob Feenstra for data on prices and quantities sold for many of the early 1980s full-size vans and sport utilities.

a vehicle-year observation. Econometrically, nameplate/year observations that lie in adjacent years and do not change horsepower, wheelbase, width or length by more than 10 percent are treated as the same model. Given this definition, there are 916 independent observations.

Consumer information comes from the Consumer Expenditure Survey (CEX), a rotating panel that records U.S. household purchasing patterns. I use the years 1987-1992, which includes almost 30,000 observations on U.S. households, to approximate the empirical distribution function of demographics in the U.S.

I also use the CEX automobile supplement, which allows me to link demographics of new vehicle purchasers to the vehicles they purchase. I observe 2660 new vehicle purchases in the supplement over this 6 year period. I use these purchases to estimate new vehicle purchase probabilities for different income groups.<sup>8</sup> The survey also allows me to identify the subset of purchasers for vehicles of principle interest to my questions, including purchasers of minivans, station wagons, sport-utility vehicles, and full-size vans. The sample sizes are limited as I observe 120, 63, 131, and 23 observations respectively. However, this does provide me with reasonably precise estimates of average family size and head-of-household age for purchasers of each of these vehicle types.<sup>9</sup>

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<sup>8</sup>While there are about 200 different kinds of vehicles marketed annually, only 400 new vehicle purchases are reported annually, frustrating efforts to use the micro data directly. See Goldberg (1995) for a more complete discussion of these data.

<sup>9</sup>I also use some annual information from other sources. The number of households ( $M$ ) in the U.S. comes from the *Statistical Abstract of the U.S.*, as do prices for a gallon of unleaded gas in the 1990s. Gasoline prices in the 1980s are taken from the U.S Department of Commerce's *Business Statistics*.

## 7 Estimation

My estimation strategy closely resembles the Generalized Method of Moments (GMM) approach taken by BLP, except that I supplement their moments with a new set of micro moments.

### 7.1 The Micro Moments

The idea for using these additional moments derives from Imbens and Lancaster (1994). They suggest that aggregate data may contain useful information on the average of micro variables. In my case, the CEX automobile supplement provides information on aggregates of new car purchasers. The GMM estimation routine essentially chooses the parameter estimates to match (in part) the average model predictions to the observed averages from the CEX outcomes.

I use three sets of additional moments. The first matches average probability of new vehicle purchase conditional on income level. These moments are given by

$$E[\{i \text{ purchases new vehicle}\} | \{y_i < \bar{y}_1\}],$$

$$E[\{i \text{ purchases new vehicle}\} | \{\bar{y}_1 \leq y_i < \bar{y}_2\}], \text{ and}$$

$$E[\{i \text{ purchases new vehicle}\} | \{y_i \geq \bar{y}_2\}],$$

where  $\{i \text{ purchases new vehicle}\}$  is the event that consumer  $i$  purchases a new vehicle, and  $\{y_i < \bar{y}_1\}$ ,  $\{\bar{y}_1 \leq y_i < \bar{y}_2\}$ , and  $\{y_i \geq \bar{y}_2\}$  are, respectively, the events that consumer Figures on GNP are drawn from the *Economic Report of the President*. Finally, the log-normal parameters of the distribution of income in the U.S. were estimated using data from the annual March Current Population Surveys (used for the random coefficients approach with just aggregate data.)

$i$  is in the low, middle, and high income group. I also match the model predicted averages to those observed in the CEX for the moments

$$E[fs_i | \{i \text{ purchases a minivan}\}],$$

$$E[fs_i | \{i \text{ purchases a station wagon}\}],$$

$$E[fs_i | \{i \text{ purchases a sport utility}\}], \text{ and}$$

$$E[fs_i | \{i \text{ purchases a full-size van}\}],$$

the average family size of purchasers of minivans, station wagons, sport utilities, and full-size vans, respectively. Finally, I include four moments that match the probability head-of-household is between age 30 and 60 for each of these four family vehicle groups.

## 7.2 The BLP Moments

One might describe the BLP approach as using two different sets of moments. The first set of moments matches the model's share predictions ( $s_j(\delta(\theta), \theta)$ ) to those in the data ( $\mathbf{s}_j$ ), or

$$s_j(\delta(\theta), \theta) - \mathbf{s}_j = 0, \quad j=0,1,\dots,J.$$

This moment matching is equivalent to solving for the vector  $\delta(\theta)$  of product dummy variables that matches the predicted to the observed market shares, which Berry (1994) shows exists and is unique under mild regularity conditions on the distribution of consumer tastes.

The second set of moments relates to the market-level disturbances ( $\xi_j(\theta), \omega_j(\theta)$ ). Except for price, the unobserved demand and supply disturbances for any vehicle  $j$  are

assumed to be uncorrelated with observed demand and cost side variables of all vehicles in that year, or

$$E[\xi_j(\theta_0) | (X, W)] = E[\omega_j(\theta_0) | (X, W)] = 0.$$

I follow BLP's approximation to the optimal instruments. Product  $l$ 's characteristics are valid instruments for themselves. For prices, two sets of instruments are available. The first set are cost side variables that are excluded from the demand equation. The second set derive from the equilibrium first order conditions from (5.2), where firm  $f$ 's choice of its product  $l$ 's price is determined by its proximity in characteristics space to competing products and to its own-firm products. In any year, a first order approximation to the optimal instruments is given by the sum of the characteristic  $k$  across other own-firm products, or  $\sum_{j \neq l, j \in J_f} x_{jk}$ , and the sum of the characteristic across competing firms, or  $\sum_{j \notin J_f} x_{jk}$ .<sup>10</sup>

### 7.3 The Objective Function

The two sets of moments that enter the GMM objective function are  $G_1(\theta)$ , the BLP-like moments, and  $G_2(\theta)$ , the moments associated with the CEX data. The population moment conditions are assumed to uniquely equal zero at the truth  $\theta_0$ , or

$$E[G(\theta_0)] = E \begin{bmatrix} G_1(\theta_0) \\ G_2(\theta_0) \end{bmatrix} = 0.$$

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<sup>10</sup>Bresnahan, Stern, and Trajtenberg (1997) provide a nice discussion of the intuition behind using these instruments.

I follow Hansen (1982), who shows that the optimal (two-step) GMM estimator takes the form

$$\hat{\theta} = \arg \min_{\theta \in \Theta} G^*(\theta)'G^*(\theta),$$

where  $G^*(\theta) = a(\tilde{\theta})\hat{G}(\theta)$ ,  $\hat{G}(\cdot)$  is the sample analog to  $G(\cdot)$ , and  $a(\tilde{\theta})$  is a consistent estimate of the “square root” of the inverse of the asymptotic variance-covariance matrix of the moments (obtained using  $\tilde{\theta}$ , a preliminary consistent estimate of  $\theta_0$ ).

The two sources of variance in  $V = E[ G^*(\theta_0)G^*(\theta_0)' ]$  come from two independent sampling processes, so  $V$  is block diagonal. Letting  $\Gamma = E \left[ \frac{\partial G^*(\theta_0)}{\partial \theta} \right]$ , the gradient of the moments with respect to the parameters evaluated at the true parameter values, the asymptotic variance of  $\sqrt{n}(\hat{\theta} - \theta_0)$  is given by

$$(\Gamma' \Gamma)^{-1} \Gamma' V \Gamma (\Gamma' \Gamma)^{-1}.$$

Reported standard errors estimate  $\Gamma$  and  $V$  using the consistent estimates  $\Gamma(\hat{\theta})$  and  $V(\hat{\theta})$ .<sup>11</sup>

## 8 Results

### 8.1 Descriptive Statistics

The average characteristics of new vehicles sold in the United States are reported in Table 1a, including averages for the different *family vehicles* (minivans, station wagons, sport

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<sup>11</sup>Moment restrictions for models that are similar in nameplate and characteristics over time are aggregated into one sample observation. Thus, the standard errors of the parameter estimates permit product-specific errors for similar models to exhibit arbitrary correlation across years.

utility vehicles, and full-size vans.)<sup>12</sup> Except for the small, inexpensive station wagons, family vehicles were priced competitively with one another and differed from other vehicles primarily in their size. Most minivans and station wagons came equipped with front wheel drive (FWD), with Chrysler almost exclusively accounting for the 63% of FWD minivan sales. Minivans also had the distinction of coming with more “luxury”; 78% had air conditioning (the luxury proxy) as part of the standard list price package.

Table 1b summarizes income, family size, and head-of-household age for different new vehicle purchasers and for the United States population as a whole. New vehicle purchasers had an average income of \$36,113, about \$13,000 higher than the average income of U.S. households (1982-84 CPI adjusted). Minivans, station wagons, sport-utilities, and full-size vans were most often purchased by larger families, and by households whose head is between the age of 30 and 60. In particular, for family vehicles minivans had the highest average family size (3.86) and the highest fraction of head of households between the age of 30 and 60 (78%).

Table 1c presents summary sales figures for the family-vehicle market segment from 1981-93. Minivan sales climbed over the 1980s, moving from a market share of 1.5% in 1984 to almost 10% in 1993. The waning appeal of station wagons was closely correlated with the success of minivans. They captured approximately 10% of the new car market in each year 1981, 1982, and 1983, but in the minivan’s introductory year their sales started to fall. Sales continued to fall every year until 1991. This negative correlation in sales

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<sup>12</sup>Petrin (2001) contains a more complete set of results including a number of robustness checks and an appendix that describes computational details.

is consistent with a positive covariance in taste for these vehicles. A related finding is in column 5, where the sum of station wagon and minivan sales is reported. While the market share for station wagons fell and the share of minivans climbed, the sum of the shares remained fairly constant over the sample period.

## 8.2 Parameter Estimates

Tables 2a and 2b report the results for the four different demand-side models: OLS, IV, random coefficients with IV correction, and random coefficients with IV correction and the CEX data. Estimated sensitivity to price almost doubles when moving from OLS to IV (similar to BLP's finding), suggesting that instrumenting will be important in any final specification. OLS and IV restrict the random coefficients (reported in Table 2b) to be zero. As many of these estimates are significantly different from zero, they lead Wald tests to reject these two specifications in favor of the more flexible frameworks.

The third column of Table 2a and first column of Table 2b contain the complete set of random coefficient demand estimates obtained using just the market-level data. Only 6 of 24 demand side parameter estimates have t-statistics that are greater than 1, and none of the eight coefficients that relate to the family vehicles has a t-statistic that is greater than 1.

The final columns in both tables present results for the random coefficients model estimated using the micro moments. 21 of the 24 parameter estimates now have t-statistics greater than 1. The parameters most closely related to the additional information show

the biggest increase in precision, as all 11 coefficients related to family vehicles and income effects have t-statistics greater than 3. Thus, the micro moments combined with the 13 years of market-level data provide sufficient information to precisely estimate many of the model's parameters, especially those most relevant for the welfare questions.

Results from the regression of the (log of) estimated marginal costs on the vehicle characteristics are presented in Table 2c. All of the car characteristics enter with significant coefficients that are of the expected sign. It costs more to build more acceleration, bigger vehicles (measured by weight), better fuel efficiency, and more luxury into a new vehicle. I now turn to the implications of these demand and supply estimates.

### **8.3 Changes in Consumer Welfare: 1984**

I use compensating variation to measure changes in consumer welfare from the minivan introduction. This cost of living index is the change in a consumer's income that equates utility in a particular economic environment to some chosen benchmark utility (see Hicks (1946).) For the benchmark I use the standard of living attained with minivans available as a choice. In the counterfactual environment there are no minivans and other vehicle prices solve the set of equilibrium first order conditions from (5.2) (without minivans). Compensating variation is the dollar amount a consumer would need to be just indifferent between the equilibrium with minivans and the one without them. Thus, for minivan purchasers it is the dollar amount a (former) minivan consumer needs to be compensated at the new equilibrium prices to achieve the "minivan standard of living".

Table 3a summarizes the implied equilibrium price changes (with the micro data) that occur with the minivan's entry in 1984. They suggest that the Dodge Caravan had many substitutes that were top-selling vehicles in the large sedan and wagon segments of the market. In particular, station wagons (SW) experienced the largest percentage price decreases upon entry, and the large family sedans (LS) show the largest dollar decreases (\$100-\$150). For non-minivan purchasers, compensation is determined entirely by changes (mostly decreases) in vehicle prices associated with the entry of minivans. Overall, in 1984 the estimated gains to non-minivan purchasers from increased price competition accounts for almost 43% of the total consumer benefits.

Table 3b presents summary statistics for the distribution of compensating variation for minivan purchasers under each of the four demand-side models. I begin with the OLS and IV logit models, which have no random coefficients and use no micro data. Estimated average compensation is \$13,652 and \$7,414 respectively. Since the sum of compensation and the price paid equals the willingness-to-pay, OLS and IV imply that 1984 minivan consumers would have willingly spent (on average) \$22,374 and \$16,136 respectively to obtain a minivan. Such willingness-to-pay estimates seem inconsistent with profit-maximizing behavior by Chrysler and unlikely given the wide selection of vehicles available at significantly lower prices.

The table also decomposes compensating variation into two components.<sup>13</sup> One component is related to the observed characteristics entering the utility function. The second

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<sup>13</sup>Because of income effects this decomposition is approximate for the random coefficients models.

component is related to the idiosyncratic logit taste term. OLS and IV welfare estimates suffer from a heavy dependence on the latter term. Minivan consumers require an average of \$95,121 (\$51,663) compensation for loss of the characteristics captured by the idiosyncratic minivan taste relative to the second choice vehicle. The OLS and IV results also imply that minivan consumers *strongly dislike* the observed characteristics of this vehicle relative to their second choice.

Compensating variation falls to \$3,171 when heterogeneity in taste is allowed (and instruments continue to be used). The decomposition improves in the sense that the magnitude of the idiosyncratic term falls significantly. However, the welfare change is still dominated by this component, and consumers of minivans still dislike the utility provided by its observed characteristics. The model estimates also imply that only the wealthiest (and least price sensitive) households purchase new vehicles, as average purchaser income from the model exceeds that observed in the CEX by almost \$60,000.

Once the random coefficients model is augmented with data on consumer observables, the average compensating variation falls to \$1,247. At \$851, compensation arising from the loss of the minivan's observed characteristics (relative to the second choice vehicle) is now positive. The welfare change implied by the idiosyncratic logit term is \$396, much smaller than the three alternative approaches. Finally, with the micro moments the implied average income conditional on new minivan purchase is \$36,091, about \$3,000 less than the CEX estimate of \$39,476.

Chart 1 plots the distributions of compensating variation for the IV logit model, the

random coefficients approach without micro data, and the full model. Here the “extreme-taste” consumers are very apparent. Estimates from the IV logit model (the top histogram) imply that 10% of minivan purchasers would have needed at least \$20,000 in compensation. With the random coefficients (the second histogram), the tail is much less pronounced, although there are still many consumers who would have needed thousands of dollars in compensation to relinquish their minivan. Adding the information from the micro moments (the third histogram) appears to significantly reduce the “extreme-tastes” tail. The cumulative weight of these results leads me to prefer the full model with micro moments when estimating changes in welfare.

## 8.4 Markups, Producer Surplus, and Profit Dissipation

Before focusing exclusively on the results using micro data, I compare estimated markups across the demand-side models. Table 4a summarizes these markups. In the case of the OLS and IV logit, implied markups averaged \$13,904 and \$7,551.<sup>14</sup> Observed prices less estimated markups yield estimates of marginal costs. They are negative for 73% and 22% of vehicles respectively, reflecting the low estimated demand elasticities under OLS and IV.<sup>15</sup> They illustrate how demand-side bias can transmit itself to the supply side when

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<sup>14</sup>Note also that the ratio of the estimated markups from the OLS and IV logit frameworks, \$13,904/\$7,551, is almost exactly equal to the ratio of the price-sensitivity coefficients, a result that obtains from the logit framework.

<sup>15</sup>Many of the estimated own-price elasticities are less than one, making them inconsistent with static profit maximizing behavior in an oligopolistic market.

marginal costs are estimated in this manner.

Markups from the random coefficients model restricted to market-level data (column 3) and the full model (column 4) are all positive. The average markup with random coefficients but no micro data is about twice that of the average markup when micro data is added to the framework (40% vs. 17%). Both are well within the range of previously reported estimates.<sup>16</sup>

I now focus exclusively on results using the micro data. Table 4b reports sales-weighted average prices and percentage markups (estimated markups divided by observed prices) for selected vehicle groups from 1983-1987. Minivans enjoyed consistently larger markups than station wagons, sport-utility vehicles, and other new vehicles, in part derived from their location in a less-crowded region of product space. Station wagon markups were 2% to 3% lower on average than minivan markups, and consistently fell below the market average. Overall, markups fell over this time period as the number of vehicle choices increased from 157 in 1983 to 198 in 1987.

Changes in Chrysler's, Ford's and GM's estimated total variable profits due to the

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<sup>16</sup>Two estimates of markups from the same time period come from BLP and Goldberg (1995). BLP use market-level data from 1971-1990 on the U.S. passenger car market (i.e. no minivans, sport-utilities, or vans). Their random coefficients model yields ranges of markups depending upon the cost and demand side specification that range from as small as 15% to 25% to as large as 30% to 40%. Goldberg (1995) uses a nested-logit framework with the same market-level data as BLP (only using 1983-87) and combines this data with consumer-level information from the CEX. She finds an average markup of 38%, with a range from 14% to 61%. She also reports implied estimates for markups ranging from 15% to 50% using separate information from the Annual Survey of Manufacturers and Consumer Reports.

introduction of the minivan are reported in Table 4c. These numbers obtain by computing implied profits with no minivans and comparing them to estimated profits with minivans (see Section 5.) They suggest Chrysler benefited significantly from introducing the minivan, as variable profits increased by \$202 million (14%) in the first year relative to what profits would have been without the introduction. Sales and estimated markups continued to grow over the next few years. By the end of 1987, Chrysler's minivans had generated almost \$1.5 billion in estimated profits, exceeding the reported \$700 million spent on the cost of development.<sup>17</sup>

Ford and GM quickly responded to Chrysler with their own versions of minivans. However, these minivans were built on down-sized full-size-van platforms, and thus were more like their predecessors than Chrysler's front-wheel-drive family van. In the end, both Ford and GM were hurt by Chrysler's innovation, with the results suggesting a fall in variable profits between 1% to 2% annually (for high volume GM, this amounted to hundreds of millions of dollars).

Profit dissipation is reported in Table 4d, which compares Chrysler's implied profits with Ford and GM minivans removed from the market to the estimated profits that obtain

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<sup>17</sup>This \$700 million figure was reported in the March 21, 1983 issue of Time magazine. Other figures include an estimate from the November 14, 1983 issue of Fortune, which reported a \$400 million cost of retooling at the first minivan plant (a lower bound on total development costs.) Chrysler's total planned investment in new products was reported to be \$1.5 billion in 1983 (Ward's Automotive, 1983). Of course, some of the initial design of the minivan had been completed by DeLaRussa while he worked at Ford in the 1970s.

with all minivans in the market. Over four years GM and Ford cannibalized an estimated \$126 million dollars of Chrysler's profits, which amounts to profits equivalent to a loss in sales of 76,000 minivans. While these losses are not trivial, Chrysler's minivan appears to have differentiated itself enough to maintain some market power.

## **8.5 Total Welfare Change: 1984-88**

Table 5 summarizes changes in consumer and producer welfare across the industry for the years 1984-88. Consumers benefited significantly, gaining a new product for which some households, especially those with large families, had strong taste. Additionally, non-minivan consumers benefit from the price competition, obtaining \$157 million of the \$367 million in consumer gains for 1984. It also appears that the industry (ex post) would have been willing to pay Chrysler not to produce the minivan, as total producer surplus for the industry fell slightly in 1984 and 1985. Finally, the total welfare gain over the first five years was about \$2.9 billion dollars, of which \$2.8 billion came from consumer surplus. Thus, estimated benefits from this new product introduction were far larger than both the costs to society of producing the vehicle and the private returns the innovator obtained.

## **9 Conclusions**

In this paper I report two main findings. One is a technique I find useful for estimating demand curves. The second quantifies how the minivan introduction changed consumer

and producer welfare in the United States.

I suggest a technique for obtaining more precise estimates of demand curves when consumer-level data is not available. My recommendation is to supplement market-level data with information relating demographic averages of consumers to the products that they purchase. The extra information plays the same role as consumer-level data, allowing estimated substitution patterns and (thus) welfare to directly reflect demographic-driven differences in tastes for observed characteristics. The technique should be useful for a broad range of markets where price and product characteristics data may not be sufficient to precisely identify the relevant substitution patterns. In the minivan case, I find that the micro data are important for demand and welfare measurement, primarily because they appear to free the model from a heavy dependence on the idiosyncratic logit error.

My results suggest that overall gains from the minivan introduction were large and that consumer benefits far outweighed the costs of development and the profits obtained by the innovator. Consumer benefits were distributed across households in a non-random way, and almost half of these benefits came from increased price competition and accrued to non-minivan purchasers. On the producer side, the results were mixed. Chrysler obtained large benefits from the minivan introduction, easily recouping its initial development costs. These sales came at the expense of the rest of the industry, which was unprepared for the minivan innovation and unable to respond quickly with the introduction of a comparable product.

These results support a story where large improvements in consumers' standard of

living arise from competition between firms. These firms ignore the externalities they impose upon one another, cannibalizing each other's profits by introducing new and different goods. The new goods that successfully differentiate themselves from existing products can yield large profits for the innovator and substantial gains for consumers.

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TABLE 1a  
Average (Sales-Weighted) Characteristics for Selected Vehicle Types, 1981-93

|                             | All Vehicles |        | Minivans | St. Wagons<br>p <\$7,7,54 | St. Wagons<br>p ≥\$7,7,54 | Sport Utilities | Full Size Vans |
|-----------------------------|--------------|--------|----------|---------------------------|---------------------------|-----------------|----------------|
|                             | Mean         | StdDev |          |                           |                           |                 |                |
| Horsepower/Weight           | 0.39         | 0.07   | 0.36     | 0.35                      | 0.37                      | 0.40            | 0.30           |
| Length*Width*Height         | 0.71         | 0.13   | 0.87     | 0.60                      | 0.78                      | 0.83            | 1.13           |
| A/C Standard                | 0.27         | 0.44   | 0.78     | 0.00                      | 0.16                      | 0.56            | 0.37           |
| Miles/Dollar                | 24.11        | 6.55   | 22.84    | 26.50                     | 22.24                     | 20.20           | 17.56          |
| Front Wheel Drive           | 0.64         | 0.48   | 0.63     | 0.83                      | 0.60                      | 0.00            | 0.00           |
| List Price (1982-84 CPI \$) | 9,867        | 4,559  | 10,060   | 6,864                     | 10,421                    | 10,949          | 10,321         |

Notes:

- 1) List price is base model price.
- 2) Lowest list-price quartile of station wagons separated out from the top 75%.

TABLE 1b  
Average Consumer Characteristics for the U.S. and Selected Sub-Populations, 1987-92

|             | U.S.   |        | New Vehicle Purchasers | Minivan Purchasers | St. Wagon Purchasers | Sport Util Purchasers | FS Van Purchasers |
|-------------|--------|--------|------------------------|--------------------|----------------------|-----------------------|-------------------|
|             | Mean   | StdDev |                        |                    |                      |                       |                   |
| Income      | 23,728 | 21,255 | 36,113                 | 39,476             | 40,196               | 41,569                | 31,164            |
| Family Size | 2.58   | 1.53   | 2.87                   | 3.86               | 3.17                 | 2.97                  | 3.47              |
| MidAge      | 0.55   | 0.49   | 0.64                   | 0.78               | 0.73                 | 0.74                  | 0.65              |

Notes:

- 1) Source is the Consumer Expenditure Survey.
- 2) Income is measured in 1982-84 CPI adjusted dollars.
- 3) Family size is number of household members.
- 4) MidAge is binary variable for head of household age between 30 and 60 inclusive.

TABLE 1c  
 Family Vehicle Sales as a Percent of Total Vehicle Sales  
 U.S. Automobile Market, 1981-1993

| Year | Minivans | Station Wagons | Sport Utilities | Full Size Vans | Minivans + Sta. Wagons | U.S. Auto Sales Millions |
|------|----------|----------------|-----------------|----------------|------------------------|--------------------------|
| 1981 | 0.00     | 10.51          | 0.58            | 0.82           | 10.51                  | 7.58                     |
| 1982 | 0.00     | 10.27          | 0.79            | 1.17           | 10.27                  | 7.05                     |
| 1983 | 0.00     | 10.32          | 3.51            | 1.04           | 10.32                  | 8.48                     |
| 1984 | 1.58     | 8.90           | 5.51            | 1.20           | 10.48                  | 10.66                    |
| 1985 | 2.32     | 7.33           | 6.11            | 1.05           | 9.65                   | 11.87                    |
| 1986 | 3.63     | 6.70           | 5.73            | 0.85           | 10.43                  | 12.21                    |
| 1987 | 4.86     | 6.47           | 6.44            | 0.73           | 11.33                  | 11.21                    |
| 1988 | 5.97     | 5.14           | 7.18            | 0.69           | 11.11                  | 11.76                    |
| 1989 | 6.45     | 4.13           | 7.47            | 0.61           | 10.58                  | 11.06                    |
| 1990 | 7.95     | 3.59           | 7.78            | 0.27           | 11.54                  | 10.51                    |
| 1991 | 8.29     | 3.05           | 7.80            | 0.29           | 11.34                  | 9.75                     |
| 1992 | 8.77     | 3.07           | 9.33            | 0.39           | 11.84                  | 10.12                    |
| 1993 | 9.93     | 3.02           | 11.66           | 0.29           | 12.95                  | 10.71                    |

TABLE 2a  
Parameter Estimates for the Demand Side Equation

| Variable           | OLS                               | IV                 | Random             | Random                       |
|--------------------|-----------------------------------|--------------------|--------------------|------------------------------|
|                    | Logit                             | Logit              | Coefficients       | Coefficients<br>& Micro Data |
|                    | Price Coefficients ( $\alpha$ 's) |                    |                    |                              |
| $\alpha_1$         | 0.07<br>(0.01)**                  | 0.13<br>(0.01)**   | 4.92<br>(9.78)     | 7.52<br>(1.24)**             |
| $\alpha_2$         |                                   |                    | 11.89<br>(21.41)   | 31.13<br>(4.07)**            |
| $\alpha_3$         |                                   |                    | 37.92<br>(18.64)** | 34.49<br>(2.56)**            |
|                    | Base Coefficients ( $\beta$ 's)   |                    |                    |                              |
| Constant           | -10.03<br>(0.32)**                | -10.04<br>(0.34)** | -12.74<br>(5.65)** | -15.67<br>(4.39)**           |
| Horsepower/Weight  | 1.48<br>(0.34)**                  | 3.78<br>(0.44)**   | 3.40<br>(39.79)    | -2.83<br>(8.16)              |
| Size               | 3.17<br>(0.26)**                  | 3.25<br>(0.27)**   | 4.60<br>(24.64)    | 4.80<br>(3.57)*              |
| Air Cond. Standard | -0.20<br>(0.06)**                 | 0.21<br>(0.08)**   | -1.97<br>(2.23)    | 3.88<br>(2.21)*              |
| Miles/Dollar       | 0.18<br>(0.06)**                  | 0.05<br>(0.07)     | -0.54<br>(3.40)    | -15.79<br>(0.87)**           |
| Front Wheel Drive  | 0.32<br>(0.05)**                  | 0.15<br>(0.06)**   | -5.24<br>(3.09)    | -12.32<br>(2.36)**           |
| Minivan            | 0.09<br>(0.14)                    | -0.10<br>(0.15)    | -4.34<br>(13.16)   | -5.65<br>(0.68)**            |
| Station Wagon      | -1.12<br>(0.06)**                 | -1.12<br>(0.07)**  | -20.52<br>(36.17)  | -1.31<br>(0.36)**            |
| Sport Utility      | -0.41<br>(0.09)**                 | -0.61<br>(0.10)**  | -3.10<br>(10.76)   | -4.38<br>(0.41)**            |
| Full Size Van      | -1.73<br>(0.16)**                 | -1.89<br>(0.17)**  | -28.54<br>(235.51) | -5.26<br>(1.30)**            |
| % Change GNP       | 0.03<br>(0.01)**                  | 0.03<br>(0.01)**   | 0.08<br>(0.02)**   | 0.24<br>(0.02)**             |

Notes:

Standard errors in parentheses.

\* - t-statistic > 1

\*\* - t-statistic > 2

Quadratic time trend included in all specifications.

CEX is the Consumer Expenditure Survey.

TABLE 2b  
Random Coefficient Parameter Estimates

| Variable          | Random Coefficients ( $\gamma$ 's) |                        |
|-------------------|------------------------------------|------------------------|
|                   | Uses No<br>Micro Data              | Uses CEX<br>Micro Data |
| Constant          | 1.46<br>(0.87)*                    | 3.23<br>(0.72)**       |
| Horsepower/Weight | 0.10<br>(14.15)                    | 4.43<br>(1.60)**       |
| Size              | 0.14<br>(8.60)                     | 0.46<br>(1.07)         |
| A/C Standard      | 0.95<br>(0.55)*                    | 0.01<br>(0.78)         |
| Miles/Dollar      | 0.04<br>(1.22)                     | 2.58<br>(0.14)**       |
| Front Wheel Drive | 1.61<br>(0.78)**                   | 4.42<br>(0.79)**       |
| $\gamma_{mi}$     | 0.97<br>(2.62)                     | 0.57<br>(0.10)**       |
| $\gamma_{sw}$     | 3.43<br>(5.39)                     | 0.28<br>(0.09)**       |
| $\gamma_{su}$     | 0.59<br>(2.84)                     | 0.31<br>(0.09)**       |
| $\gamma_{pv}$     | 4.24<br>(32.23)                    | 0.42<br>(0.21)**       |

Notes:

The OLS and IV models assume these random coefficients are zero.  
Standard errors in parentheses.

\* – t-statistic > 1

\*\* – t-statistic > 2

Quadratic time trend included in all specifications.

CEX is the Consumer Expenditure Survey.

*mi* - minivan, *sw* - station wagon, *su* - sport utility, *pv* - full-size passenger van.

TABLE 2c  
 Parameter Estimates for the Cost Side  
 Dependent Variable: Estimated (log of) Marginal Cost

| Variable ( $\tau^2$ s)                 | Parameter<br>Estimate | Standard<br>Error |
|--|-----------------------|-------------------|
| Constant                               | 1.50                  | 0.08              |
| $\ln(\text{HorsePower}/\text{Weight})$ | 0.84                  | 0.03              |
| $\ln(\text{Weight})$                   | 1.28                  | 0.04              |
| $\ln(\text{MPG})$                      | 0.23                  | 0.04              |
| A/C Standard                           | 0.24                  | 0.01              |
| Front Wheel Drive                      | 0.01                  | 0.01              |
| Trend                                  | -0.01                 | 0.01              |
| Japan                                  | 0.12                  | 0.01              |
| Japan*Trend                            | -0.01                 | 0.01              |
| Europe                                 | 0.47                  | 0.03              |
| Europe*Trend                           | -0.01                 | 0.01              |
| $\ln(q)$                               | -0.05                 | 0.01              |

TABLE 3a  
Equilibrium Prices With and Without the Minivan, 1984  
1982-84 CPI Adjusted Dollars

|                                   | Price:          |                    | $\Delta$ Price | % $\Delta$ Price |
|-----------------------------------|-----------------|--------------------|----------------|------------------|
|                                   | With<br>Minivan | Without<br>Minivan |                |                  |
| Largest Price Decreases On Entry: |                 |                    |                |                  |
| GM Oldsmobile Toronado LS         | 15,502          | 15,643             | -141           | 0.90             |
| GM Buick Riviera LS               | 15,379          | 15,519             | -139           | 0.89             |
| GM Buick Electra LS               | 12,843          | 12,978             | -135           | 1.04             |
| GM Chevrolet Celebrity SW         | 8,304           | 8,431              | -127           | 1.51             |
| Ford Cadillac Eldorado LS         | 19,578          | 19,704             | -126           | 0.64             |
| Ford Cadillac Seville LS          | 21,625          | 21,749             | -125           | 0.57             |
| GM Pontiac 6000 SW                | 9,273           | 9,397              | -123           | 1.31             |
| GM Oldsmobile Ciera SW            | 9,591           | 9,714              | -123           | 1.27             |
| GM Buick Century SW               | 8,935           | 9,056              | -121           | 1.34             |
| GM Oldsmobile Firenza SW          | 7,595           | 7,699              | -104           | 1.35             |
| Largest Price Increases On Entry: |                 |                    |                |                  |
| Chrysler LeBaron SW               | 9,869           | 9,572              | 297            | 3.10             |
| Volkswagen Quattro SW             | 13,263          | 13,079             | 184            | 1.41             |
| Chrysler (Dodge) Aries K SW       | 7,829           | 7,659              | 170            | 2.22             |
| AMC Eagle SW                      | 10,178          | 10,069             | 109            | 1.08             |

Notes:

- 1) Equilibrium prices without minivans estimated using model with micro data and Bertrand-Nash first order conditions.
- 2) Vehicle codes:  
LS - Large Sedan  
SW - Station Wagon
- 3) Bertrand-Nash pricing with random coefficients does not a priori determine signs of firm-specific price changes.

TABLE 3b  
Average Compensating Variation Conditional on Minivan Purchase, 1984  
1982-84 CPI Adjusted Dollars

|  | OLS<br>Logit | IV<br>Logit | Random<br>Coefficients | Random<br>Coefficients<br>& Micro Data |
|--|--------------|-------------|------------------------|--|
| <hr/>  |              |             |                        |  |
| Compensating Variation:                            |              |             |                        |  |
| Median   | 9,573        | 5,130       | 1,217                  | 783                                    |
| Mean   | 13,652       | 7,414       | 3,171                  | 1,247                                  |
| <hr/>  |              |             |                        |  |
| Welfare Change From Difference In:                 |              |             |                        |  |
| Observed Characteristics ( $\delta_j + \mu_{ij}$ ) | -81,469      | -44,249     | -820                   | 851                                    |
| Logit Error ( $\epsilon_{ij}$ )                    | 95,121       | 51,663      | 3,991                  | 396                                    |
| <hr/>  |              |             |                        |  |
| Income of Minivan Purchasers:                      |              |             |                        |  |
| Estimate from Model                                | 23,728       | 23,728      | 99,018                 | 36,091                                 |
| Difference from Actual (CEX)                       | -15,748      | -15,748     | 59,542                 | -3,385                                 |

Notes:

Compensating variation evaluated at equilibrium prices without minivans.

Decomposition of compensation is the average difference in value of observed and unobserved characteristics between first and second choices.

For logit models purchase decision is independent of income, so mean purchaser income is mean U.S. household income.

TABLE 4a  
 Implied Markups Derived From Demand-Side Estimates and Bertrand-Nash  
 Pricing Assumption, 1981-1993 (2407 models)

| Statistic  | \$ and % Markups Using: |             |                        |       |  |       |
|--|-------------------------|-------------|------------------------|-------|--|-------|
|  | OLS<br>Logit            | IV<br>Logit | Random<br>Coefficients |       | Random<br>Coefficients<br>& Micro Data |       |
|  | \$                      | \$          | \$                     | %     | \$                                     | %     |
| Median   | 13,834                  | 7,513       | 2,593                  | 36.7% | 1,439                                  | 15.0% |
| Mean   | 13,904                  | 7,551       | 4,017                  | 40.7% | 1,753                                  | 16.7% |
| 10%  | 13,647                  | 7,413       | 1,628                  | 27.8% | 819                                    | 11.2% |
| 90%  | 14,297                  | 7,765       | 8,357                  | 62.6% | 2,856                                  | 24.8% |
| Standard Deviation                                 | 257                     | 140         | 4,089                  | 14.0% | 1,229                                  | 6.2%  |
|  |                         |             |                        |       |  |       |
| % of Estimated Marginal<br>Costs That Are Negative | 73.7%                   | 22.6%       | 0%                     |       | 0%                                     |       |

Note:

% markups are estimated markups divided by observed prices. They are not reported for IV and OLS logit because the estimated marginal cost is negative for many vehicles. Dollars are 1982-84 CPI adjusted.

TABLE 4b  
 Average (Sales-Weighted) Markup/Price and Price, 1983-1987

| Year | Minivans |       | Station<br>Wagons |       | Sport-Utility<br>Vehicles |        | All Other<br>Vehicles |        |
|------|----------|-------|-------------------|-------|---------------------------|--------|-----------------------|--------|
|      | %        | \$    | %                 | \$    | %                         | \$     | %                     | \$     |
| 1983 | –        | –     | 18.27%            | 8,230 | 17.28%                    | 9,715  | 18.85%                | 9,059  |
| 1984 | 19.19%   | 8,722 | 17.83%            | 8,400 | 17.07%                    | 9,952  | 17.72%                | 9,085  |
| 1985 | 19.43%   | 8,655 | 16.81%            | 8,412 | 16.51%                    | 9,904  | 17.12%                | 9,101  |
| 1986 | 17.33%   | 8,898 | 15.82%            | 9,164 | 15.41%                    | 10,115 | 16.43%                | 9,480  |
| 1987 | 16.31%   | 9,527 | 13.86%            | 9,620 | 14.06%                    | 11,123 | 14.79%                | 10,053 |

Notes:

% markups are estimated markups divided by observed prices. Dollars are 1982-84 CPI adjusted.

TABLE 4c  
 Change in Industry and Big Three Total Variable Profits  
 With the Advent of Minivans

| Year | Industry | Chrysler   |       | Ford       |       | GM         |       |
|------|----------|------------|-------|------------|-------|------------|-------|
|      |          | \$Millions | %     | \$Millions | %     | \$Millions | %     |
| 1984 | -0.21%   | 202.5      | 14.38 | -31.8      | -1.16 | -155.8     | -1.50 |
| 1985 | -0.13%   | 259.1      | 13.99 | -37.4      | -1.29 | -171.0     | -1.63 |
| 1986 | 0.14%    | 201.1      | 12.42 | 54.7       | 1.84  | -119.9     | -1.09 |
| 1987 | 0.17%    | 346.1      | 23.27 | -22.8      | -0.66 | -174.5     | -2.14 |
| 1988 | 0.65%    | 504.1      | 32.50 | -24.7      | -0.70 | -235.4     | -2.90 |

Note:

These numbers are computed using the model to estimate profits both with minivans in the market and with minivans removed from the market (see Section 5.)

TABLE 4d  
 Chrysler's Profit Dissipation With Entry  
 Ford, GM Minivans

| Year | Change In Total Variable Profits |       |
|------|----------------------------------|-------|
|      | \$Millions                       | %     |
| 1985 | -6.06                            | -0.16 |
| 1986 | -22.72                           | -1.99 |
| 1987 | -42.35                           | -2.25 |
| 1988 | -55.68                           | -2.63 |

Note:

These profit changes are computed using the model (see text.)

TABLE 5  
The Change In U.S. Welfare From the Minivan Innovation, 1984-1988

| Year  | Compensating<br>Variation<br>\$Millions | Change in<br>Producer Profits<br>\$Millions | Welfare<br>Change<br>\$Millions |
|-------|---|---|---------------------------------|
| 1984  | 367.29                                  | -36.68                                      | 330.61                          |
| 1985  | 625.04                                  | -25.07                                      | 599.97                          |
| 1986  | 439.93                                  | 27.30                                       | 467.23                          |
| 1987  | 596.59                                  | 29.75                                       | 626.34                          |
| 1988  | 775.70                                  | 110.24                                      | 885.94                          |
| Total | 2804.55                                 | 105.54                                      | 2910.09                         |

Note. – Computations done using 1982-84 CPI Adjusted Dollars.

